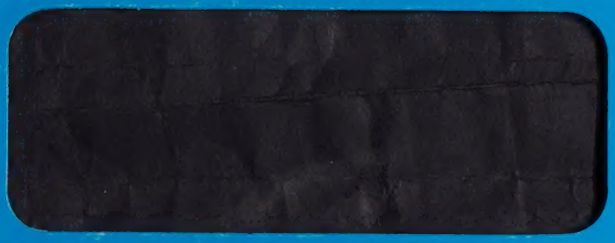

GOULD
Electronics

GOULD BRUSH

MANUAL PART NO.
13-804215-02

HIGH GAIN D.C. PREAMPLIFIERS

MODEL 13 4215 02 and 13 4215 12

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3631 Perkins Avenue-Cleveland, Ohio 44114

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10-1-85

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Phone: (201) 935-1717

SAN FRANCISCO
GOULD INC., TMSD
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Hayward, California 94545
Phone: (415) 782-0852

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ALLAN CRAWFORD ASSOC., LTD.
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Mississauga, Ontario L4Z1Y2
Phone: (416) 890-2010

WASHINGTON, D.C.
GOULD INC., TMSD
6301 Ivy Lane Suite 106
Greenbelt, Maryland 20770
Phone: (301) 345-0050

EUROPE

GOULD INSTRUMENTS S.A.F.
57 Rue St. Sauveur 91160
Ballainvilliers, France
Phone: 011-33-6-934-1067

GOULD INSTRUMENTS GMBH
Dieselstrasse 5-7
D-6453-Seligenstadt,
West Germany
Phone: 06182-2107

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Section I
General Information

1.1 INTRODUCTION

The Brush High Gain D.C. Preamplifiers, Models 13-4215-02 and 13-4215-12 (with Zero Suppression) are single channel, plug-in units. (see Figs. 1-1 and 1-2) Both units are engineered specifically for signal amplification to a matching Brush pen-drive oscillograph system equipped with Brush engineered chart paper.

These chopper-driven amplifiers feature basic sensitivities of 100 microvolts per chart paper division (gain of 1,000), and completely self-contained power supplies.

Figure 1-1 Model 13-4215-02

Figure 1-1 Model 13-4215-12

1.2 SPECIFICATIONS

Measurement Range	100 microvolts/division to 500 volts full scale
Attenuator Steps	100, 200, 500 microvolts/division; 1, 2, 5, 10, 20, 50, 100 microvolts/division; OFF, plus x100 multiplier (+ 1.0%)
Input Circuit	Balanced, floating, guarded
Input Impedance (when operating)	1 megohm constant

NOTE: Input impedance of approximately 990K ohms can be maintained when the power is removed, by placing x1-x100 switch in the x100 position.

Common Mode Rejection	
D.C. at 1 Kohm unbalance	160 db
60 Hz at 1 Kohm unbalance	130 db
60 Hz at 10 Kohm unbalance	120 db
Maximum Safe Common Mode Voltage	500 volts
Gain Instability With Respect To:	
Time	±0.1 division/week
Temperature	±0.01%/℃
Line	±0.01%/±10% line change
Zero Line Instability With Respect To:	
Time	±0.1 division/week
Temperature	±0.1 division/10℃
Line	±0.1 division/±10% line change
Noise Peak-to-Peak on Chart at Maximum Sensitivity	0.25 division at 100 Kohm source
Non-Linearity (peak-to-peak)	±0.2%(% of full scale)
Step Response (Preamp Only)	Less than 2 milliseconds (10%-90% full scale)

Zero Suppression (13-4215-12 only)	
Range	x1 position: -1.0, -0.1, OFF, +0.1 and +1.0 volts x100 position: -100, -10, OFF, +10 and +100 volts
Inaccuracy	Calibration ±0.5% Dial Setting ±0.5%
Instability	Time: ±0.02%/week Temp: ±0.02%/℃ Line: ±0.02%/+10% change
Resolution	±0.5% of range
Frequency Response	
D.C. to 75 Hz	Flat ±1% full scale
D.C. to 100 Hz	Flat ±5% full scale
D.C. to 200 Hz	Flat ±10% full scale
Power Requirements	
Voltage	115 volts A.C. ±13%
Frequency	50 to 2,000 Hz
Power	8 volts amp nominal
Warm-up Time	15 minutes to full accuracy
Environment	
Storage Temperature	-40℃ to +85℃
Operating Temperature	0℃ to +55℃
Temperature Within Spec	+15℃ to +35℃
Humidity	95% at 32℃
Controls	Attenuator, x1-x100 switch, Variable Gain, Pen Position Model 13-4215-12 only: above plus Suppression Range switch and 10-turn calibrated suppression vernier

Physical Characteristics

Height	7 inches
Width	2-1/8 inches
Depth	15-1/2 inches
Weight	9 lbs

1.3 ACCESSORIES

Extender Cable for Operating 4200 series Preamplifier	342960-915
Signal Input Connector	231977-910
Signal Output and Power Connector	123837

Section II
Installation

2.1 GENERAL

This section describes the checks and inspections that should be made upon receipt of the Brush High Gain D.C. Preamplifier; installation procedures, signal input connections, and outline dimensions.

2.2 INITIAL INSPECTION

Before attempting any electrical connections or operation, visually examine unit for broken or loose knobs, broken or chipped rear connectors, and dented or nicked panels.

2.3 INSTALLATION

The High Gain D.C. Preamplifier may be installed in any of the Brush Preamplifier mounting frames. To install preamplifier, slide preamplifier into rack until rear connectors engage, and secure with two knurled screws on front panel.

2.4 SIGNAL INPUT CONNECTIONS

The "Balanced, Floating and Guarded" D.C. Amplifier is the most sophisticated of all amplifier types and can be used with all types of self generating signal sources. Both of its input terminals are isolated from the amplifier chassis and also isolated from the output. The input terminals also have equal impedance to a third terminal called the Guard Shield or GUARD, which is a full floating internal shield. The guard is used to minimize capacity from signal input terminals to chassis ground and to improve the A.C. common mode rejection of the amplifier.

Both amplifier input terminals are free to float up or down in compliance with any common mode voltage that may appear at the signal source. Since both input terminals are floating and have very low capacity to chassis ground, incoming signals may be grounded, floating or driven off ground without affecting accuracy or system noise. When the guard shield is properly connected the A.C. noise rejection characteristics are quite good so this amplifier can be used over a wide range of signal amplitudes down to and including the microvolt level. The guard shield is not internally connected but it is brought out to separate terminals in the amplifier input connector so that it may be properly connected for wide variety of signal sources.

This type of amplifier works well with all types of signal sources but it is essential that the guard shield and the signal cable shield be properly connected. A signal shield is effective only if it is maintained at a fixed potential with respect to the circuit being protected. Otherwise, the shield will drive current through its own capacity into the signal pair. The guard principle requires that the amplifier guard be driven by the common mode voltage appearing at the two active amplifier input terminals. This means that the guard must always be stabilized with respect to the incoming signal pair as shown in Figures 2-1 thru 2-6. The general rules for using an amplifier guard are:

1. Connect amplifier guard to the signal amplifier cable shield and make sure that the cable shield is insulated from chassis ground or any extension of the ground. This step extends the internal amplifier guard shield out along the entire length of the signal cable.

2. Connect center-tap of signal source to the signal cable shield. If the signal source does not have a center-tap, connect the signal cable shield to the low or shielded side of signal source. This step stabilizes the amplifier guard and signal cable shield with respect to the signal source.

3. Connect signal cable shield and its tap to the signal source to the signal ground, which should be located near the signal source. Do NOT allow either the signal pair or the signal cable shield to contact "ground" at any other point. This step limits the maximum common mode voltage to the difference in potential between the signal ground and the amplifier ground.

4. Ground the amplifier chassis, the equipment enclosure, and the low side of the amplifier output and its output cable shield to the ground. This step stabilizes the recording power line system with respect to system ground.

Connecting the signal cable shield to the signal source and grounding this point not only stabilizes the cable shield with respect to the signal but it also produces several worthwhile benefits:

1. Limits the maximum common mode voltage at the amplifier to the potential difference between signal ground and system ground;

2. Prevents signal-cable capacity from shunting the amplifier's impedance-to-ground;

3. Drains off common-mode current in cable shield before it can flow through the signal source;

4. Preserves the high common mode rejection of the amplifier.

NOTE: For signal input connections, always use special shielded connector provided with amplifier (Brush part number 231977-910).

For SINGLE ENDED-GROUNDED signal sources the amplifier input terminal (No. 2) is connected to the grounded side of the signal source and the other amplifier input terminal (No. 6) is connected to the high side of the signal source. As shown in Figure 2-1 the signal cable shield is connected to amplifier guard terminals No. 1, 3, 5, and 7, located in the input connector. The other end of the signal cable shield is connected to the low side of the signal source and to the source ground.

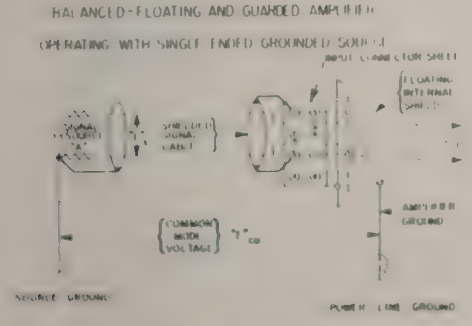


Figure 2-1 Single Ended--Grounded

For SINGLE ENDED-FLOATING signal sources the low amplifier input terminal (No. 2) is connected to the low side of the signal source and the other amplifier input terminal (No. 6) is connected to the high side of the signal source as shown in Figure 2-2. The signal cable shield is connected to amplifier guard terminals No. 1, 3, 5, and 7, located in the input connector. The other end of the signal cable shield is connected to the low side of the signal source and also to a low impedance ground located at the signal source.

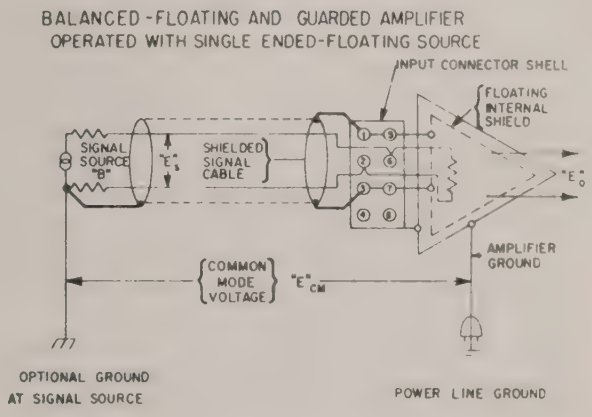


Figure 2-2 Single Ended--Floating

For SINGLE ENDED-DRIVEN OFF GROUND signal sources the low amplifier input terminal (No. 2) is connected to the low side of the signal source and other amplifier input terminal (No. 6) is connected to the high side of the signal source as shown in Figure 2-3. The signal cable shield is connected to amplifier guard terminals No. 1, 3, 5, and 7, located in the input connector. The other end of the signal cable shield is connected to the

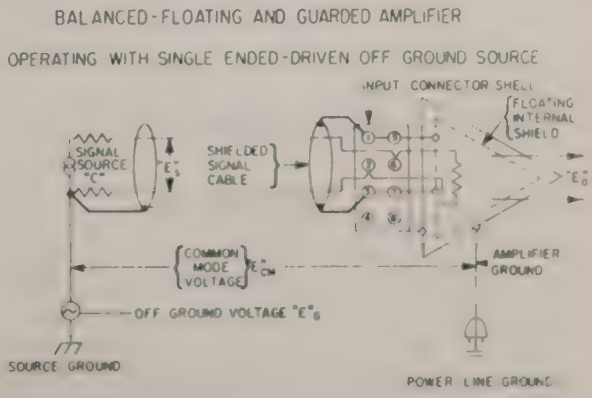


Figure 2-3 Single Ended-Driven off Ground

low side of the signal source and driven by the off ground voltage. It is essential that the signal cable have adequate insulation between the shield and the outside since it will be operating off ground.

For BALANCED-GROUNDED signal sources the two active amplifier input terminals No. 2 and 6 are connected across the signal source as shown in Figure 2-4. These connections can be reversed if a change in signal polarity is desired. The signal cable shield is connected to amplifier guard terminals No. 1, 3, 5, and 7, located in the input connector. The other end of the signal cable shield is connected to the center tap on the signal source and to the source ground.

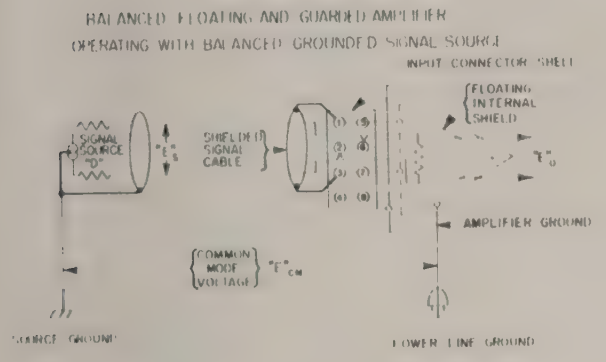


Figure 2-4 Balanced--Grounded

For BALANCED-FLOATING signal sources the two active amplifier input terminals No. 2 and 6 are connected across the signal source as shown in Figure 2-5. These connections can be reversed if a change in signal polarity is desired. The signal cable shield is connected to amplifier guard terminals No. 1, 3, 5, and 7, located in the input connector. The other end of the signal cable shield is connected to the center tap on the signal source and to a low impedance ground located out of the signal source.

For BALANCED-DRIVEN OFF GROUND signal sources the two active amplifier input terminals No. 2 and 6 are connected across the signal source as shown in Figure 2-6. These connections can be

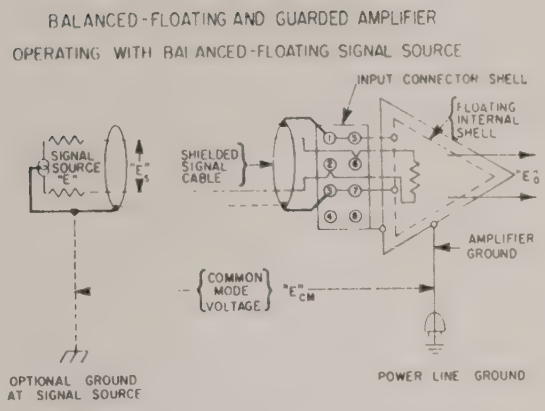


Figure 2-5 Balanced--Floating

reversed if a change in signal polarity is desired. The signal cable shield is connected to amplifier guard terminals No. 1, 3, 5, and 7 located in the input connector. The other end of the signal cable shield is connected to the center tap on the signal source and driven by the off ground voltage. It is essential that the signal cable have adequate insulation between the shield and the outside since it will be operating off ground.

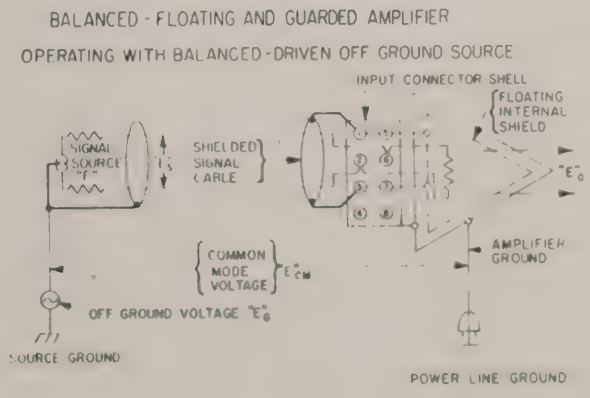


Figure 2-6 Balanced-Driven off Ground

The "Balanced, Floating and Guarded" D.C. Amplifier is generally supplied in a "FIFO" configuration which indicates Floating Input and Floating Output; both of which are isolated from each other. With a floating output, the output stage of the amplifier may be operated grounded, floating, driven off ground, or the output connections can be reversed if a change in signal polarity is desired.

2.5 OUTLINE DIMENSIONS

Refer to Figure 2-7 for dimensional outlines.

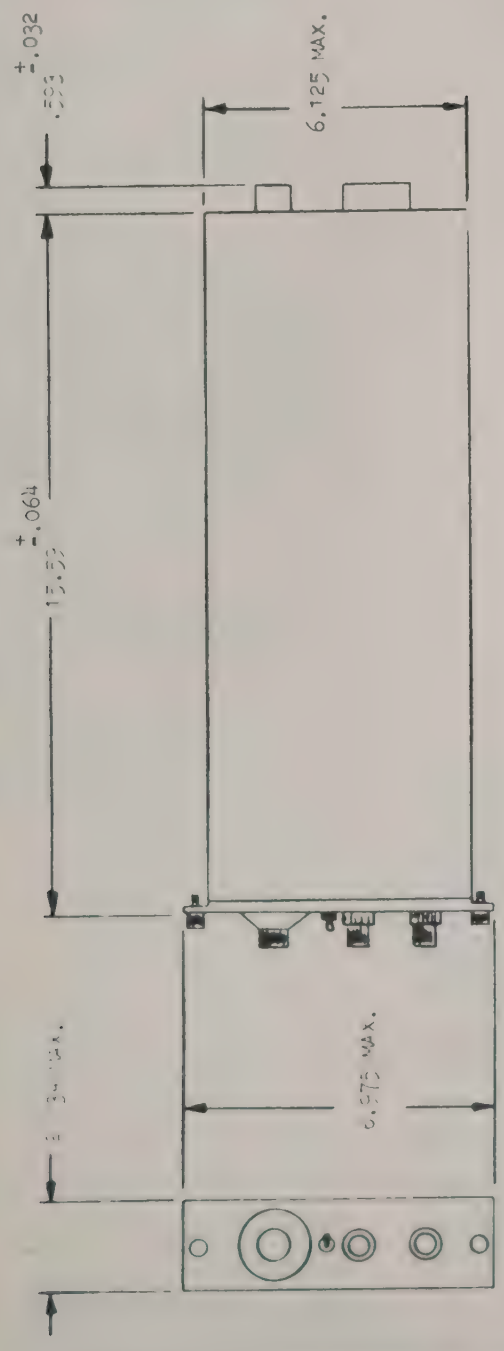


Figure 2-7 Dimensional Outline

Section III
Operation

3.1 GENERAL

The Brush High Gain D.C. Preamplifiers, Models 13-4215-02 and 13-4215-12 can be used with any signal input voltage from 100 microvolts to 500 volts and will accept either single-ended or floating input signals. A single-ended signal is obtained either from a circuit which has one terminal already at ground potential, or a circuit which will not be disturbed if one terminal is connected to ground or the amplifier chassis.

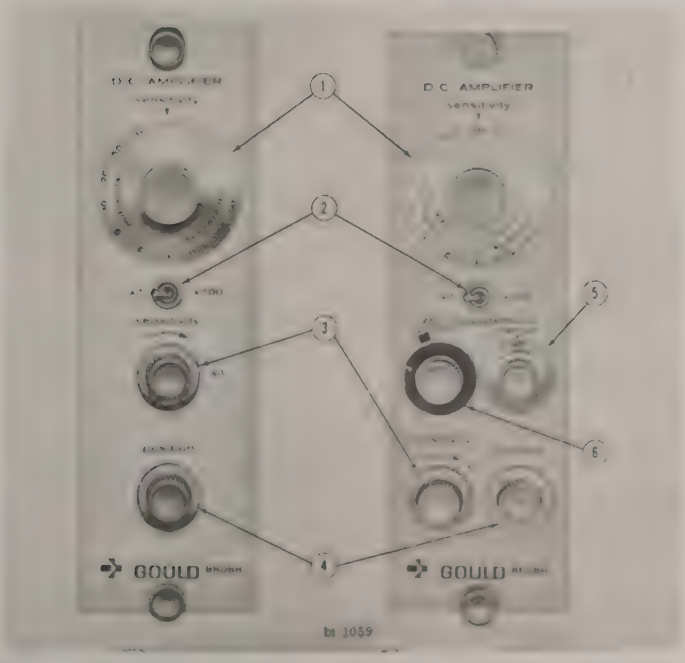
A floating signal is obtained from a circuit which will be disturbed when one terminal is connected to ground. For example, the voltage across the secondary winding of a transformer, which has an intermediate tap connected to ground, may be defined as a floating signal. If either output of this circuit were connected to ground, the transformer would be short circuited.

3.2 CONTROL DESCRIPTION

NOTE: Item numbers listed below correspond to circled number in Fig. 3-1.

Item	Control	Description
(1)	Attenuator (SENSITIVITY)	An eleven position rotary switch permits selection of 100, 200, or 500 microvolts. 1, 2, 5, 10, 20, 50, 100 millivolts per division overall system sensitivity and OFF. NOTE: OFF position does not remove operating power.
(2)	x1-x100 Multiplier Switch	Permits selecting sensitivities of 100 times indicated control markings. Sensitivities become 10, 20, 50, 100, 200, 500 millivolts, 1, 2, 5, 10 volts per division.
(3)	SENSITIVITY x1	Provides intermediate sensitivites between fixed settings of Attenuator control. When in the full clockwise (detent) position, the sensitivity is fixed as indicated on Attenuator control. When rotated counterclockwise, the sensitivity decreases from that indicated on Attenuator

Item	Control	Description
		control. A ratio of 2.5 to 1 provides overlapping gain. This control is fitted with a locking nut to prevent inadvertent turning.
(4)	PEN POSITION	Permits positioning pen across width of channel, ±28 divisions, minimum. This control is fitted with a locking knob to prevent inadvertent turning.
(5)	RANGE (Zero Suppression) (13-4215-12 only)	Permits selecting -1.0, -0.1, +0.1, +1.0 volts for calibrated zero suppression, and OFF. NOTE: When x1-x100 multiplier switch is in x100 position, range is -100, -10, +10, +100 volts and OFF.
(6)	VERNIER (Zero Suppression) (13-4215-12 only)	Permits accurate setting of zero suppression voltages. Dial reading is percentage of voltage selected on range switch. NOTE: 10.0 (extreme clockwise) is 100% of suppression voltage selected.



Model 13-4215-02 *Model 13-4215-12*

Figure 3-1 Controls Description

3.3 PRELIMINARY OPERATION

CAUTION: Check to be sure all procedures in Section II, Installation, have been performed. However, do not connect input signal to preamplifier.

1. Set Attenuator to OFF position.
2. Place x1-x100 switch in x1 position.
3. Turn SENSITIVITY x1 control to full clockwise position (detent) and secure with locking knob.
4. Place PEN POSITION control at approximate center position.
5. Set Zero Suppression RANGE switch to OFF. (13-4215-12 only).
6. Turn Zero Suppression VERNIER control to 10.0, full clockwise, and lock (13-4215-12 only).
7. Apply system power.
8. Operate oscillograph at moderate chart speed.
9. Adjust PEN POSITION control to place pen at chart center and secure with locking knob.
10. Stop recorder and connect input signal to preamplifier.
11. Recorder is now ready for normal operation.

3.4 OFF-CENTER ZERO OPERATION

It is often desirable to record signals which always appear on one side of zero. In such cases, the PEN POSITION control is used to displace the output reference voltage. Displacement may be as much as 2.5 volts either side of zero. Operation in this manner does not affect the performance of the preamplifier. Specifications remain unchanged.

3.5 UNCALIBRATED OPERATION

To obtain more useful records, it may be desirable to operate the amplifier with the SENSITIVITY vernier control backed-off from the x1 (detent) position. The only specification affected by operating the instrument in this manner is the calibrated sensitivity. All other specifications remain unchanged.

3.6 USING CALIBRATED ZERO SUPPRESSION (13-4215-12 only)

a. General

Zero suppression permits the D.C. component of a complex wave to be suppressed or bucked out, allowing the dynamic component to be amplified and recorded in greater detail. Calibrated zero suppression indicates the exact magnitude of that D.C. voltage which has been suppressed. Location of the zero suppression system between the x1/x100 switch and the amplifier's attenuator provides calibrated zero suppression that is independent of both amplifier sensitivity and attenuator setting. This valuable feature permits amplifier sensitivity and attenuator settings to be changed at any time without resetting zero suppression controls. Zener regulated zero suppression voltage and temperature compensated components assure stable zero suppression readings.

The effective use of calibrated zero suppression can best be explained by describing two typical applications.

b. Application No. 1

To determine the character of a medium level complex signal which contains a positive static component, plus one or more dynamic components, proceed as follows:

1. Turn Attenuator control to OFF position.
2. Place x1/x100 switch in the x1 position.
3. Turn Zero Suppression VERNIER to full counterclockwise position.
4. Turn SENSITIVITY x1 control to the x1 (detent) position.
5. Operate chart at 5 millimeters per second and

use PEN POSITION control to set pen at chart center.

6. Advance Attenuator control clockwise until pen approaches edge of chart. Note that the signal amplitude is less than 1 volt.

7. Set Zero Suppression RANGE control at +1 volt position which will allow complete suppression of any static component up to 1 volt. Ten revolutions of the Zero Suppression VERNIER now equal 1 volt; each revolution is equal to 100 millivolts and each dial division represents 2 millivolts.

8. Move dynamic component of signal to chart center by turning Zero Suppression VERNIER clockwise.

9. Advance Attenuator control clockwise as long as recorded trace increases in direct proportion to each increase in preamplifier sensitivity.

10. Read maximum peak-to-peak value of dynamic signal component from the recorder chart.

11. Use Zero Suppression VERNIER to adjust dynamic signal component exactly to chart center.

NOTE: In situations where the Attenuator control is at a high sensitivity position, the ability to set suppression at zero may be limited by the resolution of the Zero Suppression VERNIER control.

12. From the Zero Suppression VERNIER control, read to three places the average D.C. component of complex signal.

13. Run a short length of chart at 100 millimeters per second or higher and determine the predominating frequencies which made up the dynamic component of this complex signal.

c. Application No. 2

To be certain that Calibrated Zero Suppression is thoroughly understood, this second example describes a medium level complex signal which has a large negative static component. Since signal amplitude is greater than 2.5 volts, the input signal multiplier (x1/x100 switch) will be used in x100 position. Since static component is negative, the Zero Suppression RANGE control is set at an appropriate negative voltage position.

1. Turn Attenuator control to OFF position.

2. Place x1/x100 switch in the x100 position.

3. Turn Zero Suppression VERNIER to full counterclockwise position.

4. Turn SENSITIVITY x1 control to the x1 (detent) position.

5. Operate chart at 5 millimeters per second and use PEN POSITION control to position pen at chart center.

6. Advance Attenuator control clockwise until pen approaches edge of chart. Note that signal amplitude is slightly less than 100 volts.

7. Set Zero Suppression RANGE control to -1 volt position. Since input signal multiplier (x1/x100 switch) has been set in x100 position, a static component up to 100 volts may be completely suppression. Ten revolutions of the Zero Suppression VERNIER now equal -100 volts; each revolution is equal to -10 volts and each dial division represents -0.2 volts.

8. Turn Zero Suppression VERNIER clockwise to bring dynamic component of signal to chart center.

9. Advance Attenuator control clockwise as long as recorded trace increases directly in proportion to each increase in preamplifier sensitivity.

10. Read maximum peak-to-peak value of dynamic signal component from recorder chart.

11. Use Zero Suppression VERNIER to bring

dynamic signal component exactly to chart center.

NOTE: In situations where the Attenuator control is at a high sensitivity position the ability to set suppression at zero may be limited by the resolution of the Zero Suppression VERNIER control.

12. The average D.C. component of complex signal, to three places, is read from Zero Suppression VERNIER control.

13. Run a short length of chart at 100 millimeters per second or higher and determine the predominating frequency which makes up the dynamic component of this complex signal.

NOTE: Recorder may be stopped and recording functions interrupted at any time. However, do not remove operating power to the preamplifier with signal input connected. If signal input cannot be conveniently removed before removing operating power, place x1/x100 multiplier switch in x100 position. This will reduce loading effects on circuit being monitored. (Refer to Section 1.2 Specifications).

Section IV
Theory of Operation

4.1 GENERAL

The High Gain D.C. Preamplifier, Models 13-4215-02 and 13-4215-12 (with calibrated zero suppression) consists of a transformer-chopper input section, an A.C. amplifier circuit, and a synchronous demodulator output circuit. (see Fig. 4-1) A regulated 400 Hz power supply drives the chopper and demodulator, and is rectified to provide D.C. supply voltages for the amplifiers.

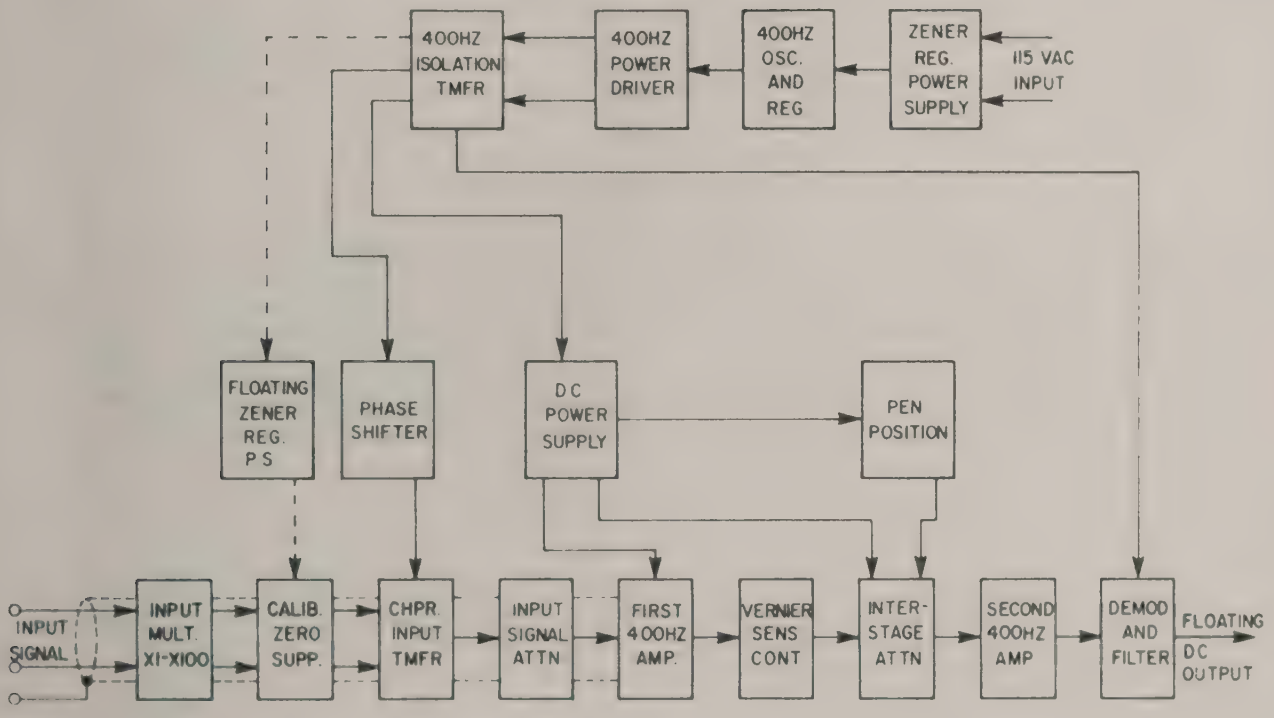


Figure 4-1 Functional Block Diagram - Model 13-4215-02 & 13-4215-12

4.2 INPUT CIRCUIT (Figure 4-2)

The input signal is applied to input multiplier, S-102, and to input transformer, T-101, and chopper, G-101. In preamplifier model 13-4215-12 a zero suppression network is positioned between input multiplier and transformer-chopper.

Zero suppression network consists of a floating, zener regulated D.C. source which supplies voltage for suppressing D.C. components of input signal. Size of inserted suppression voltage is controlled by zero suppression RANGE and VERNIER front panel controls.

The 400 Hz chopped output from transformer, T-101, is applied directly to first A.C. amplifier on five most sensitive ranges. Input attenuation to first A.C. amplifier is provided on remaining five ranges. Attenuator presents a constant 30K ohm load to transformer T-101 which is reflected to the input as one megohm.

4.3 FIRST A.C. AMPLIFIER AND INTERSTAGE ATTENUATOR (Figure 4-3)

First A.C. amplifier is an operational amplifier operated in a non-inverting configuration. This

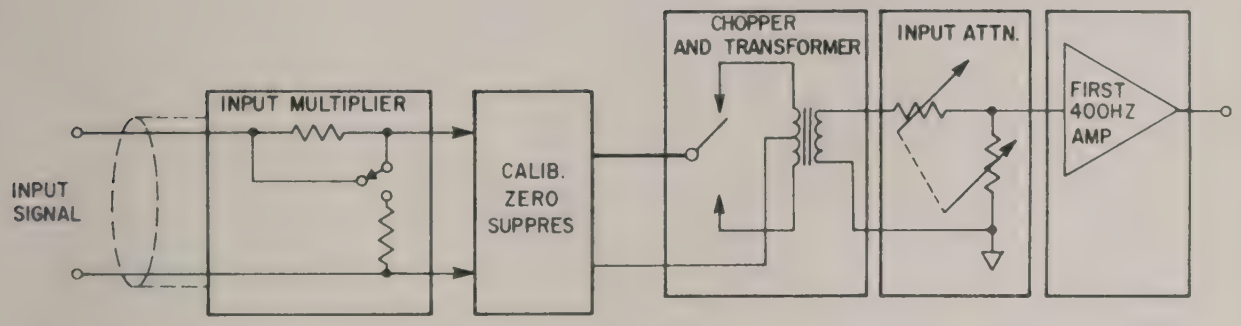


Figure 4-2 Input Circuit

mode provides high input impedance resulting in negligible loading on input attenuator. Amplifier operates at D.C. gain of unity to minimize offset errors and provide operating-point stability, and at A.C. closed loop gain of 100 at 400 Hz. Output is developed across interstage attenuator on the first five steps of the SENSITIVITY switch. This attenuator presents a constant 30K ohm load to first A.C. amplifier. A vernier SENSITIVITY x1 control provides smooth attenuation of amplifier output and has a detented position (fully clockwise) to provide factory set calibration.

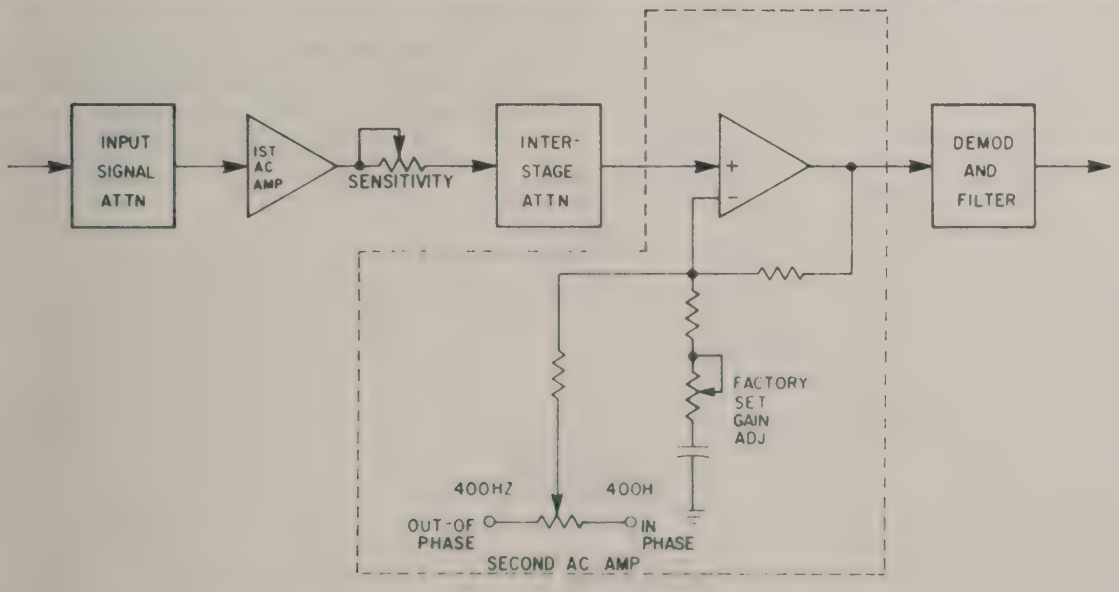


Figure 4-3 First A.C. Amplifier and Interstage Attenuator

4.4 SECOND A.C. AMPLIFIER (Figure 4-4)

Second A.C. amplifier is similar to first. Provision is made for factory set gain adjust and injection of 400 Hz signal for off-center zero operation. Either phase of 400 Hz signal is used to obtain positive or negative output offset.

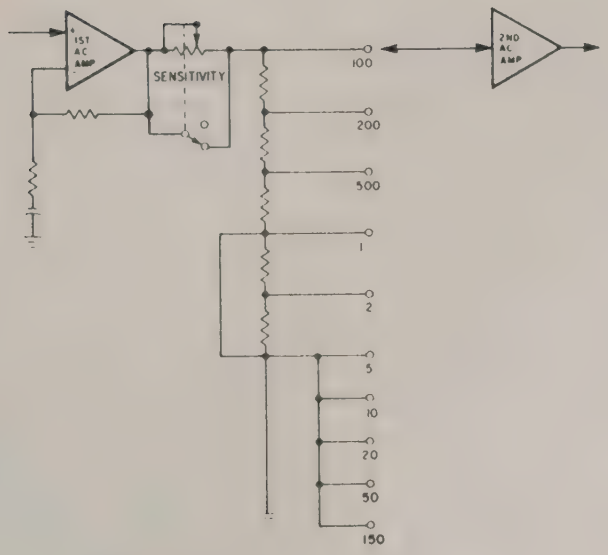


Figure 4-4 Second A.C. Amplifier

4.5 DEMODULATOR (Figure 4-5)

Demodulator consists of a synchronous transistor switch driven by 400 Hz primary supply. This type switch is reliable and has excellent temperature stability of residual D.C. offset.

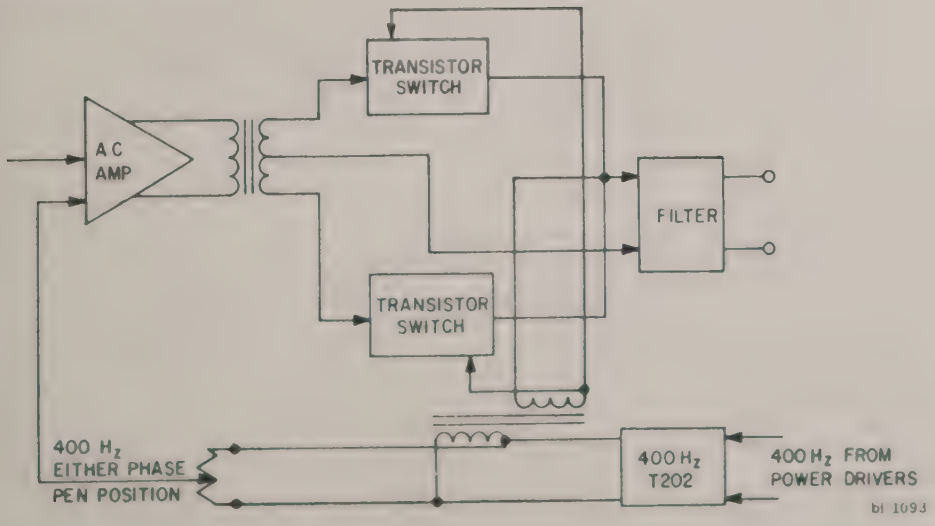


Figure 4-5 Demodulator

4.6 400 Hz SUPPLY (Figure 4-6)

Internal 400 Hz supply is line operated at 115 volts A.C., 50 to 2000 Hz or at plus or minus 150 volts D.C. This feature permits operation without need for external 400 Hz supplies.

Line input is rectified, filtered and zener regulated to provide several stable D.C. bias voltages. A 400 Hz Colpitts oscillator is operated as the collector load of one stage of a differential amplifier and regulator. The output signal is amplified by an error amplifier composed of a 2-stage voltage amplifier transformer coupled to a Class AB power driven output stage. A feedback winding on power transformer T-202 senses flux changes in the 400 Hz output signal and provides A.C. and D.C. feedback signals for control purposes. The A.C. feedback signal is fed back to the error amplifier input where it is compared to the oscillator output signal. Any difference between output and input signal results in an error signal which is then amplified forcing the output to be representative of the input. This feedback loop eliminates loading errors, reduces distortion, maintains symmetry of the output 400 Hz signal and improves linearity.

The D.C. feedback signal is compared to the reference signal with the difference representative of the error signal. The error signal is amplified by the differential amplifier and regulator with subsequent control of the amplitude of the 400 Hz oscillator output, thus providing a regulated output level.

One secondary winding of transformer T-202 provides demodulator drive and chopper drive signals. The remaining secondary winding provides a 400 Hz signal for pen position and D.C. voltages for operation of the 1st and 2nd A.C. amplifiers.

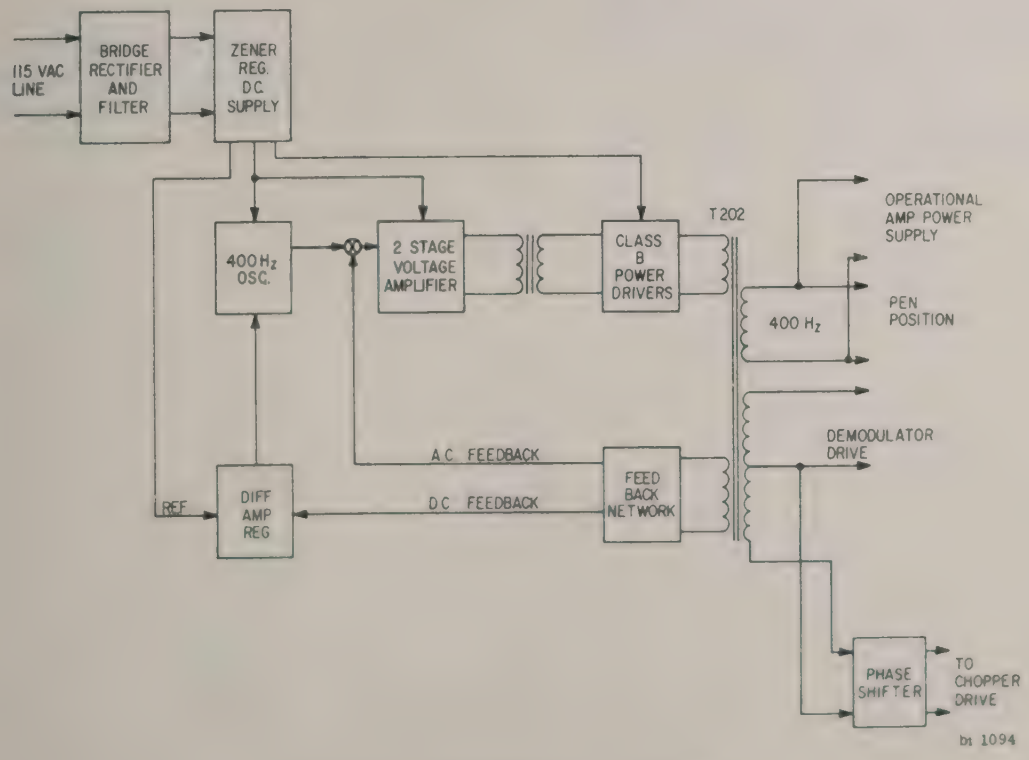


Figure 4-6 400 Hz Power Supply

Section V
Calibration

5.1 GENERAL

The Brush High Gain D.C. Preamplifiers, Models 13-4215-02 and 13-4215-12, are built to the highest precison standards, featuring maximum operational efficiency and dependability. They have been accurately calibrated and adjusted before shipment from factory, and should give long, trouble-free service. Normal aging and/or replacement of parts may require calibration.

5.2 SYSTEM CALIBRATION CHECK

At times it may be desirable to check the calibration of this preamplifier with its associated Brush recording system. To perform this check, proceed as follows:

1. Connect preamplifer to an operating Brush recording system. (Refer to Section II, Installation, of this manual.)

2. Set preamplifier SENSITIVITY control to OFF position, x1/x100 switch to x1 position, and use PEN POSITION control to set pen to exact chart center.

3. Apply a +2.500 vdc signal to preamplifier.

4. Set preamplifier SENSITIVITY to 100 mv/div.

5. Pen must deflect to exact chart left edge.

6. Reverse input signal polarity; pen must deflect to exact chart right edge.

NOTE: If pen fails to function exactly as described in steps 5 & 6 above, calibration should be checked on both the oscillograph drive amplifier and the preamplifier. Refer to oscillograph manual for proceedures covering the drive amplifiers, and refer to Para. 5.3 or 5.5 for calibration proceedures covering this preamplifier.

5.3 BENCH CALIBRATION PROCEDURE

a. Test Equipment Required

The following is a list of test equipment necessary for calibration.

NOTE: Specific manufacturer need not be adhered to, but comparable equipment is mandatory, since accuracy stated is imperative.

a. Oscilloscope, (Tektronix, Type 503, or equivalent)

b. Isolation Transformer

c. Variac -0 to 120 volts

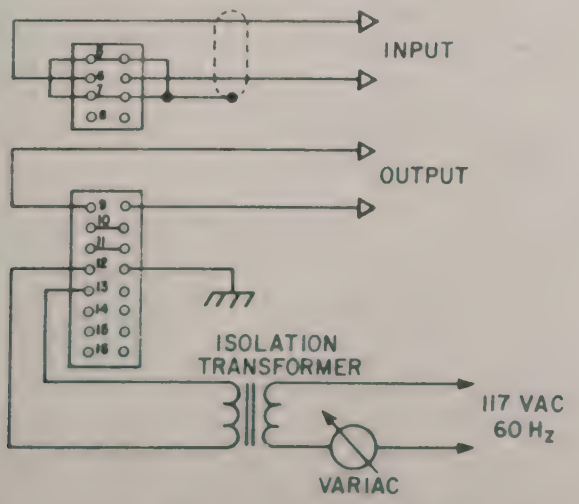


Figure 5-1 Connecting Variac and Isolation Transformer to Preamplifier

d. Variable (±5 volts) D.C. Power Supply

e. Flukemeter, 883AB or equivalent

b. Procedure

1. Remove preamplifier from mounting frame by loosening two knurled screws securing preamplifier.

2. Remove right side cover by removing nine flat-head screws.

WARNING: Power supply is operated directly off line and is not transformer coupled. Use of an isolation transformer is required as a safety precaution. Care must be exercised by calibrator when performing the following adjustments, since a shock hazard does exist with the side cover removed.

3. Refer to Figure 5-1 and connect Variac and Isolation transformer to 117 volts A.C., 60 Hz. Connect output of isolation transformer to pins 12 and 13 of mating connector of J-102.

NOTE: Power input mating connector is Amphenol 26-4200-16S (Brush part number 123837).

4. Set preamplifier controls as follows:

   Attenuator to OFF

   x1/x100 Multiplier to x1

   SENSITIVITY x1 to x1 (detent)

   PEN POSITION to approximate center of rotation

5. Set Variac to zero volts output and connect to preamplifier.

NOTE: Refer to Figure 5-2 for following adjustments and test points.

6. Connect oscilloscope from test point A(-) to test point B(+).

7. Slowly increase line voltage to 98 volts A.C. and check for sound of chopper operating.

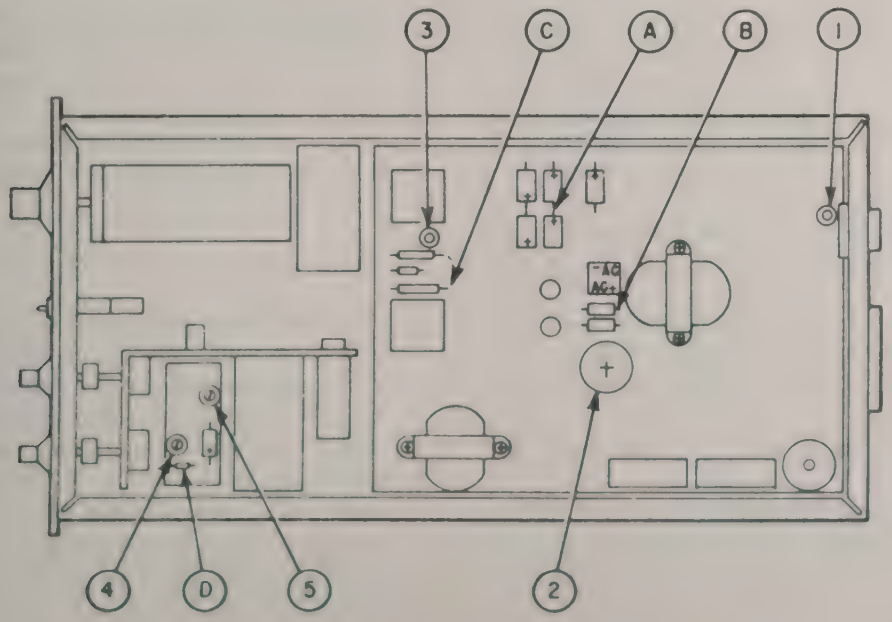


Figure 5-2 Test and Calibration Points

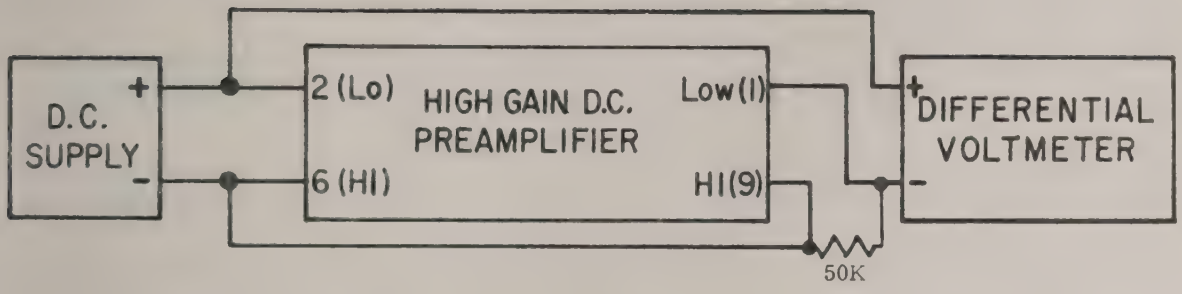


Figure 5-3 Connecting Voltmeter and DC Supply to Preamplifier

8. Adjust "line-set" resistor, R-220, item 1, until sinusoidal test signal on oscilloscope begins to flatten on either peaks. Signal should be 40 volts ±2 volts peak-to-peak.

9. Disconnect oscilloscope and increase line voltage to 117 volts.

10. Connect Flukemeter and variable D.C. power supply as shown in Figure 5-3.

11. Set D.C. power supply to zero volts.

12. Rotate PEN POSITION control to full clockwise position. Voltage output should be + 2.8 volts minimum.

13. Turn PEN POSITION control counter-clockwise slightly to set output voltage to + 2.5 volts.

14. Set Attenuator to 100 millivolts/division.

15. Increase D.C. power supply from 0 to + 5.00 volts. The input-output difference voltage as read on the fluke will be approximately 2.50 volts. As the input is varied from 0 to + 5.0 volts, adjust "phase adjust" resistor, R-228, item 2, such that the deviation around 2.5 volts is less than ±10 millivolts. The calibration point approximately corresponds to the point of maximum output obtained with a + 5.00 volts input as R-228 is varied through its range.

16. Set D.C. supply to zero and adjust PEN POSITION control for -2.5 volts.

17. Increase D.C. supply to -5.00 volts, and check for 2.5 volts ±10 millivolts null across entire range. Adjust "phase adjust" resistor, R-228 as necessary, to preserve null.

18. Repeat steps 13 through 17 as necessary to set null.

19. Remove D.C. supply and short input terminals 6 and 2.

20. Set PEN POSITION control to 0.00 volts output.

21. Remove short and apply + 2.00 volts D.C. signal to input.

22. Adjust "internal gain" resistor, R-243, item 3, for zero null ±2 millivolts.

23. Vary SENSITIVITY x1 control to extreme counter-clockwise position. Output error should be more than 0.80 volts.

24. Disconnect D.C. power supply and flukemeter.

NOTE: Calibration steps 25 through 40 apply to 13-4215-12 (with zero suppression) only. If calibrating 13-4215-02 proceed to step 41.

25. Connect oscilloscope across zener diode, CR-504, test point D, Figure 5-2.

26. Adjust "ripple adjust" resistor, R-503, item 5, for null less than one millivolt peak-to peak.

27. Set preamplifier controls as follows:

    Attenuator to OFF

    x1/x100 Multiplier to x1

    SENSITIVITY x1 to x1 (detent)

    Zero Suppression RANGE to -1.0 volts

    Zero Suppression VERNIER to 10.00

28. Connect D.C. power supply to input and fluke-meter to output.

29. Set D.C. power supply to 1.00 volt ±.05% and set Attenuator to 50 millivolts/division.

30. Adjust "1 volt set", R-506, item 4, for zero output.

31. Increase Attenuator to 5 millivolts/division and adjust "1 volt set", R-506, item 4, for zero output ±25 millivolts.

32. Disconnect D.C. power supply.

33. Set Attenuator to "10 millivolts/division."

34. Set Zero Suppression RANGE to +0.1 volts.

35. Short input terminals, pins 2 and 6.

36. Output voltage should be 1.00 volt ±5 millivolts.

37. Set Attenuator to 100 millivolts/division.

38. Set Zero Suppression RANGE to +1 volt

39. Output voltage should be 1.0 volts ±0.5%

40. Set Zero Suppression RANGE to OFF.

41. Disconnect all test equipment and replace right side cover using nine flat-head screws.

Unit is now ready for operation.

5.4 SYSTEM CALIBRATION PROCEDURE

The following calibration proceedures should only be attempted by personnel completely familiar with the principles of operation of this preamplifier. The recording system to be used in these proceedures must be accurately calibrated following the oscillograph instruction manual. If any difficulty is encountered, refer to Para. 5.3 for complete instructions.

1. Remove right side cover of the preamplifer.

2. Connect preamplifier to operating recording system using Extender cable, Brush part number 342960-915.

3. Set all controls as in step 2, Para. 5.4.

4. Apply a +2.500 vdc signal to preamplifier.

5. Adjust PHASE control (item 2, Fig. 5-2) for maximum (peak) pen deflection.

6. Adjust GAIN control (item 3, Fig. 5-2) for exactly 25 divisions, ±.25.

7. Verify preamplifier linearity by reversing input signal polarity. Pen must deflect to exact chart right edge.

8. Replace preamplifer right side cover.

9. Unit is ready for normal operation.

Section VI
Parts Identification

6.1 GENERAL

This sections contains schematics and electrical parts lists for the DC High Gain Preamplifiers, Model 13-4215-02 and 13-4215-12.

ELECTRICAL PARTS LIST
MODEL 13-4215-02 & 13-4215-12

SYMBOL NO.	PART NUMBER	DESCRIPTION
C-101	240352	Capacitor
G-101	231753	Chopper
P-101	231742	Connector, Input
P-102	123638	Connector, Output
R-101	246393-303	Resistor, Variable
R-102	241016	Resistor, Variable
R-103	R1-246659-99002	Resistor
R-104	R1-246659-10101	Resistor
R-110	240888	Resistor, Variable (-12 only)
R-112	3-263959-103	Resistor
S-101	Part of R-101	Switch
S-102	231861-910	Switch
S-103	441337	Switch (-12 only)
T-101	232223	Transformer

ELECTRICAL PARTS LIST
AMPLIFIER ASSEMBLY 864848 (-02) & 666615 (-12)

SYMBOL NO.	PART NUMBER	DESCRIPTION
AR-201	230062	Semiconductor
	240352-5R0	Capacitor
AR-202	230062	Semiconductor
	240352-5R0	Capacitor
C-201	266844-186	Capacitor
C-202	266844-186	Capacitor
C-203	262585-106	Capacitor
C-204	263343-156	Capacitor
C-205	5-241145-104	Capacitor
C-206	240352-101	Capacitor
C-207	262956-226	Capacitor
C-208	263343-156	Capacitor
C-209	240352-101	Capacitor
C-210	232920-336	Capacitor
C-211	240352-201	Capacitor
C-212	266550-686	Capacitor
C-213	240352-501	Capacitor
C-214	240352-501	Capacitor
C-215	240352-502	Capacitor
C-216	263343-156	Capacitor
C-218	5-241145-504	Capacitor
C-219	5-241145-504	Capacitor
C-220	10-241145-155	Capacitor
C-221	266550-686	Capacitor
C-222	231707-107	Capacitor
C-223	231707-107	Capacitor
C-224	266550-686	Capacitor
C-225	240352-201	Capacitor
C-226	231707-107	Capacitor
C-227	231707-107	Capacitor
C-228	231707-107	Capacitor
C-229	10-241145-404	Capacitor
C-230	10-241145-404	Capacitor
C-231	262585-475	Capacitor
C-232	262585-475	Capacitor
C-233	240352-331	Capacitor
C-235	240352-331	Capacitor
C-236	240352-331	Capacitor

ELECTRICAL PARTS LIST (Cont)
AMPLIFIER ASSEMBLY 864848 (-02) & 666615 (-12)

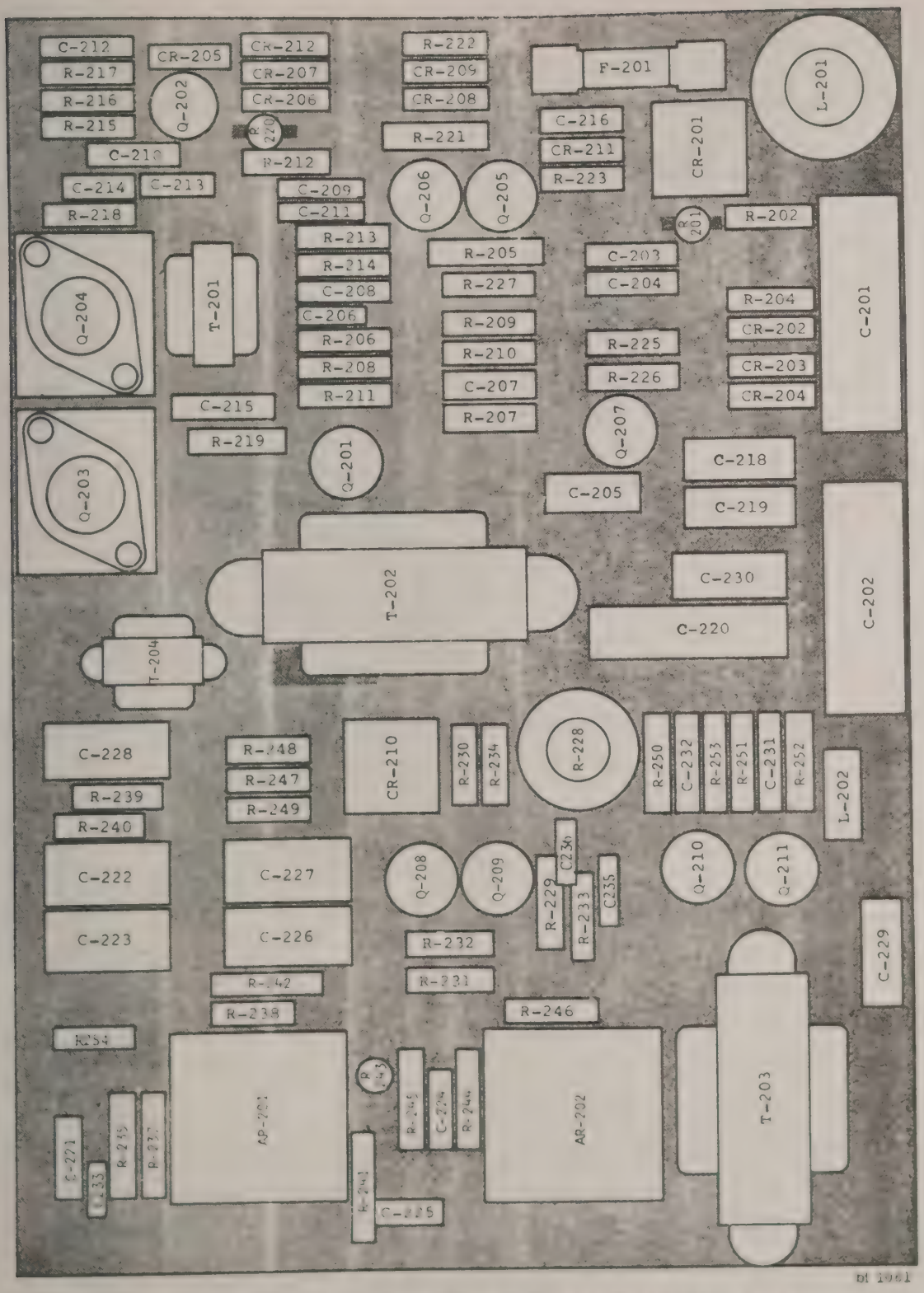
SYMBOL NO.	PART NUMBER	DESCRIPTION
CR-201	265420-2	Diode
CR-202	5-244922-13	Diode
CR-203	241133	Diode, 1N751A
CR-204	246424	Diode, 1N759
CR-205	244311	Diode, 1N277
CR-206	244311	Diode, 1N277
CR-207	244311	Diode, 1N277
CR-208	244311	Diode, 1N277
CR-209	244311	Diode, 1N277
CR-210	265420-2	Diode
CR-211	249747	Diode, 1N752
CR-212	244311	Diode, 1N277
F-201	116198-4	Fuse
L-201	263422-1	Inductor
L-202	243179	Inductor
Q-201	242323	Transistor
Q-202	242323	Transistor
Q-203	265875	Transistor
Q-204	265875	Transistor
Q-205	242323	Transistor
Q-206	242323	Transistor
Q-207	242323	Transistor
Q-208	247347	Transistor, 2N1997
Q-209	247347	Transistor, 2N1997
Q-210	240236	Transistor, 2N1303
Q-211	240237	Transistor, 2N1302
R-201	5-115558-101	Resistor
R-202	5-115557-101	Resistor
R-204	5-115557-272	Resistor
R-205	1-128182-1002	Resistor
R-206	5-115557-683	Resistor
R-207	5-115557-333	Resistor
R-208	5-115557-154	Resistor
R-209	5-115557-681	Resistor

ELECTRICAL PARTS LIST (Cont)
AMPLIFIER ASSEMBLY 864848 (-02) & 666615 (-12)

SYMBOL NO.	PART NUMBER	DESCRIPTION
R-210	5-115557-333	Resistor
R-211	5-115557-682	Resistor
R-212	5-115557-103	Resistor
R-213	5-115557-123	Resistor
R-214	5-115557-683	Resistor
R-215	5-115557-151	Resistor
R-216	5-115557-102	Resistor
R-217	5-115557-332	Resistor
R-218	5-115557-470	Resistor
R-219	5-115557-332	Resistor
R-220	265843-103	Resistor, Variable
R-221	1-128182-1002	Resistor
R-222	5-115557-153	Resistor
R-223	5-115557-822	Resistor
R-225	5-115557-153	Resistor
R-226	5-115557-683	Resistor
R-227	5-115557-153	Resistor
R-228	248813-502	Resistor, Variable
R-229	5-115557-683	Resistor
R-230	5-115557-472	Resistor
R-231	5-115557-272	Resistor
R-232	5-115557-272	Resistor
R-233	5-115557-683	Resistor
R-234	5-115557-472	Resistor
R-235	1-265969-500R0	Resistor
R-237	1-265969-50001	Resistor
R-238	5-115557-223	Resistor
R-239	5-115557-181	Resistor
R-240	5-115557-181	Resistor
R-241	1-265969-15002	Resistor
R-242	1-265969-10000	Resistor
R-243	265843-201	Resistor
R-244	1-265969-10002	Resistor
R-245	1-265969-10002	Resistor
R-246	5-115557-223	Resistor

ELECTRICAL PARTS LIST (Cont)
AMPLIFIER ASSEMBLY 864848 (-02) & 666615 (-12)

SYMBOL NO.	PART NUMBER	DESCRIPTION
R-247	5-115557-391	Resistor
R-248	5-115557-471	Resistor
R-249	5-115557-391	Resistor
R-250	5-115557-222	Resistor
R-251	5-115557-222	Resistor
R-252	5-115557-103	Resistor
R-253	5-115557-103	Resistor
R-254	5-115557-103	Resistor
T-201	266891	Transformer
T-202	265690	Transformer
T-203	265692	Transformer
T-204	266894	Transformer (-12 only)



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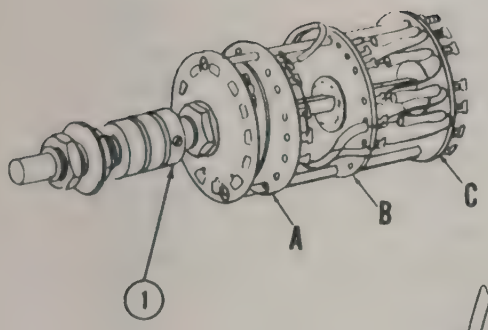
PREAMPLIFIER 400 CPS AMPLIFIER ASM.

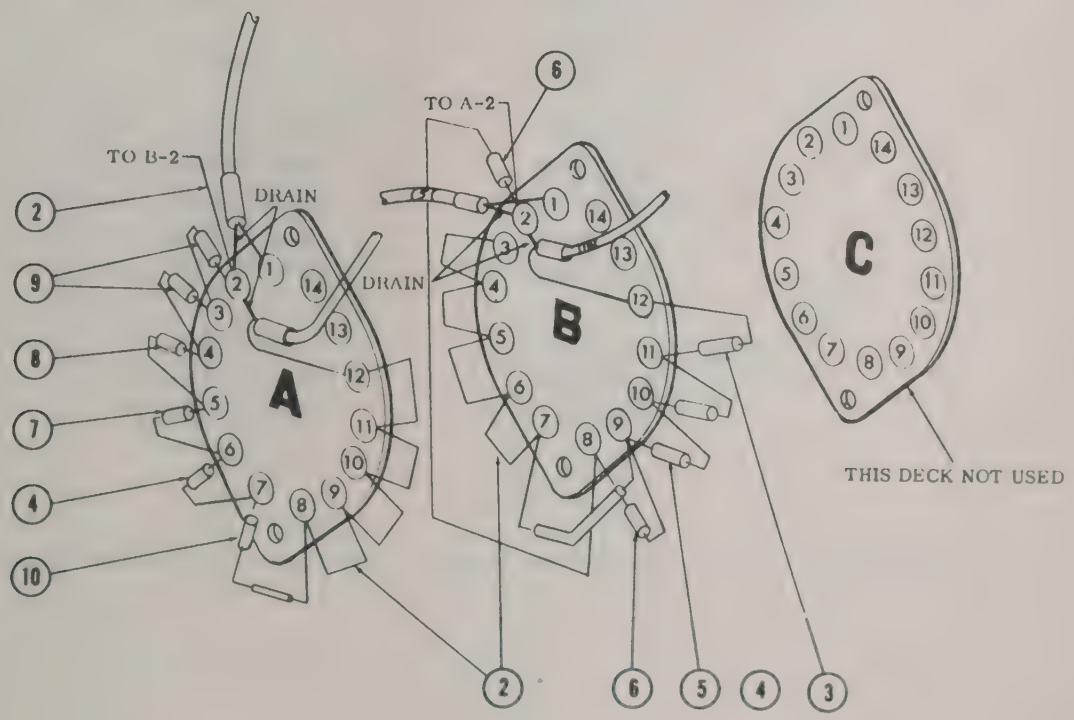
865848 (13-4215-02) OR 666615 (13-4215-12)

ELECTRICAL PARTS LIST
SWITCH ASSEMBLY 765699 (-02 &-12)

SYMBOL NO.	PART NUMBER	DESCRIPTION
R-301	25-265969-50000	Resistor
R-302	25-265969-30000	Resistor
R-303	25-265969-10000	Resistor
R-304	25-265969-500R0	Resistor
R-305	25-265969-500R0	Resistor
R-306	25-265969-24001	Resistor
R-307	25-265969-30000	Resistor
R-308	25-265969-15000	Resistor
R-309	25-265969-900R0	Resistor
R-310	25-265969-300R0	Resistor
R-311	25-265969-300R0	Resistor
S-301	266330	Switch

ITEM NO.	PART NUMBER	DESCRIPTION	SYMBOL NO.
1	266330	Switch, rotary	S-301
2	22-111759	Wire, bare	
3	25-265969-50000	Resistor	R-301
4	25-265969-30000	Resistor	R-302,R307
5	25-265969-10000	Resistor	R-303
6	25-265969-500R0	Resistor	R-304, R-305
7	25-265969-15000	Resistor	R-308
8	25-265969-900R0	Resistor	R-309
9	25-265969-300R0	Resistor	R-310, R-311
10	25-265969-24001	Resistor	R-306

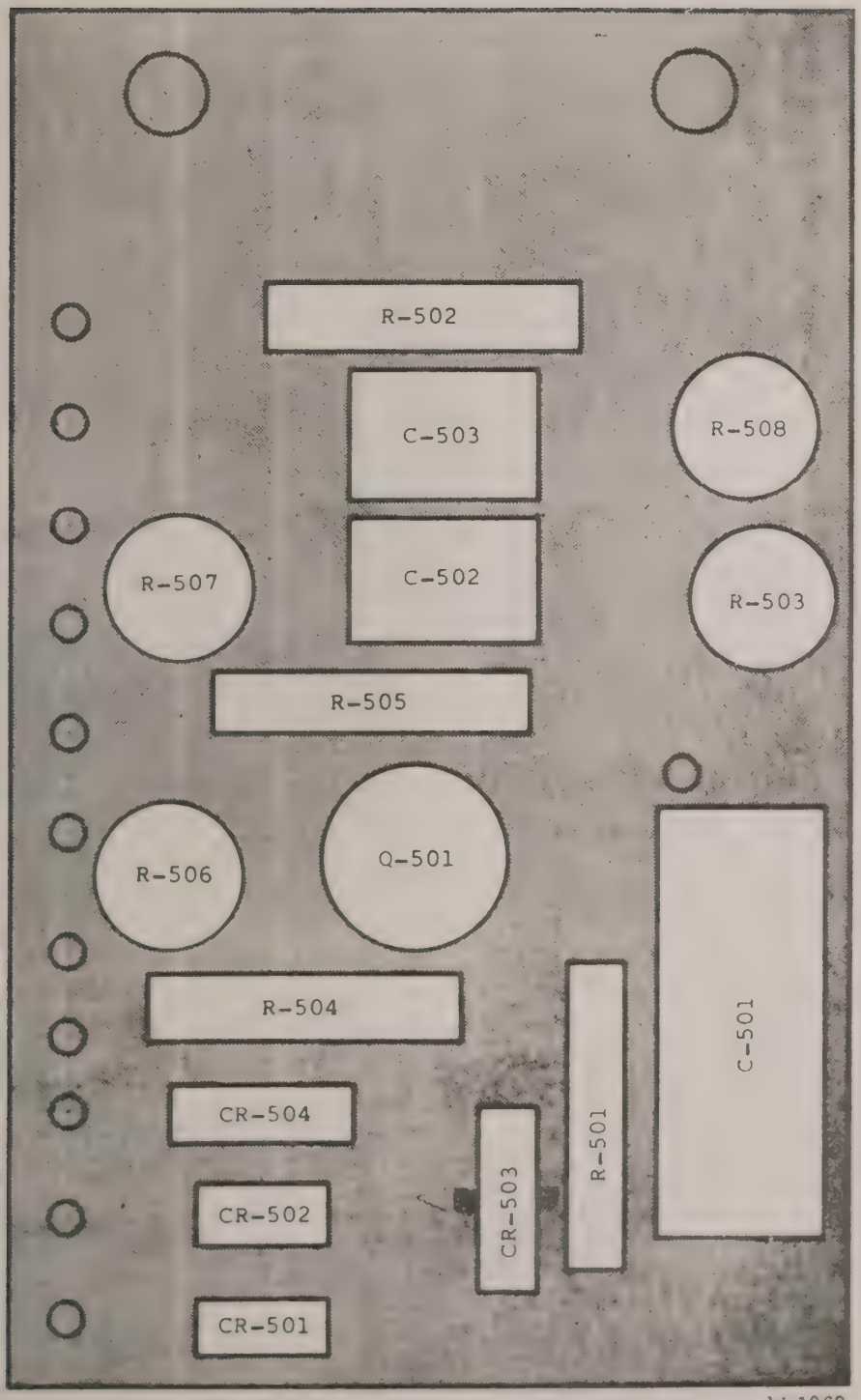




HIGH-GAIN PREAMPLIFIER
SENSITIVITY SWITCH ASM. 765699

ELECTRICAL PARTS LIST
ZERO SUPPRESSION ASSEMBLY 765897 (-12 only)

SYMBOL NO.	PART NUMBER	DESCRIPTION
C-501	243228-356	Capacitor
C-502	262956-226	Capacitor
C-503	262585-106	Capacitor
CR-501	231887	Diode
CR-502	231887	Diode
CR-503	231869	Diode, 1N816
CR-504	241133	Diode, Zener, 1N751A
Q-501	231884	Transistor, 2N1370
R-501	1-128182-50R0	Resistor
R-502	1-128182-3001	Resistor
R-503	265843-103	Resistor, Variable
R-504	1-128182-1002	Resistor
R-505	1-128182-7000	Resistor
R-506	265843-501	Resistor, Variable
R-507	R1-240971-18001	Resistor
R-508	R1-240971-20000	Resistor



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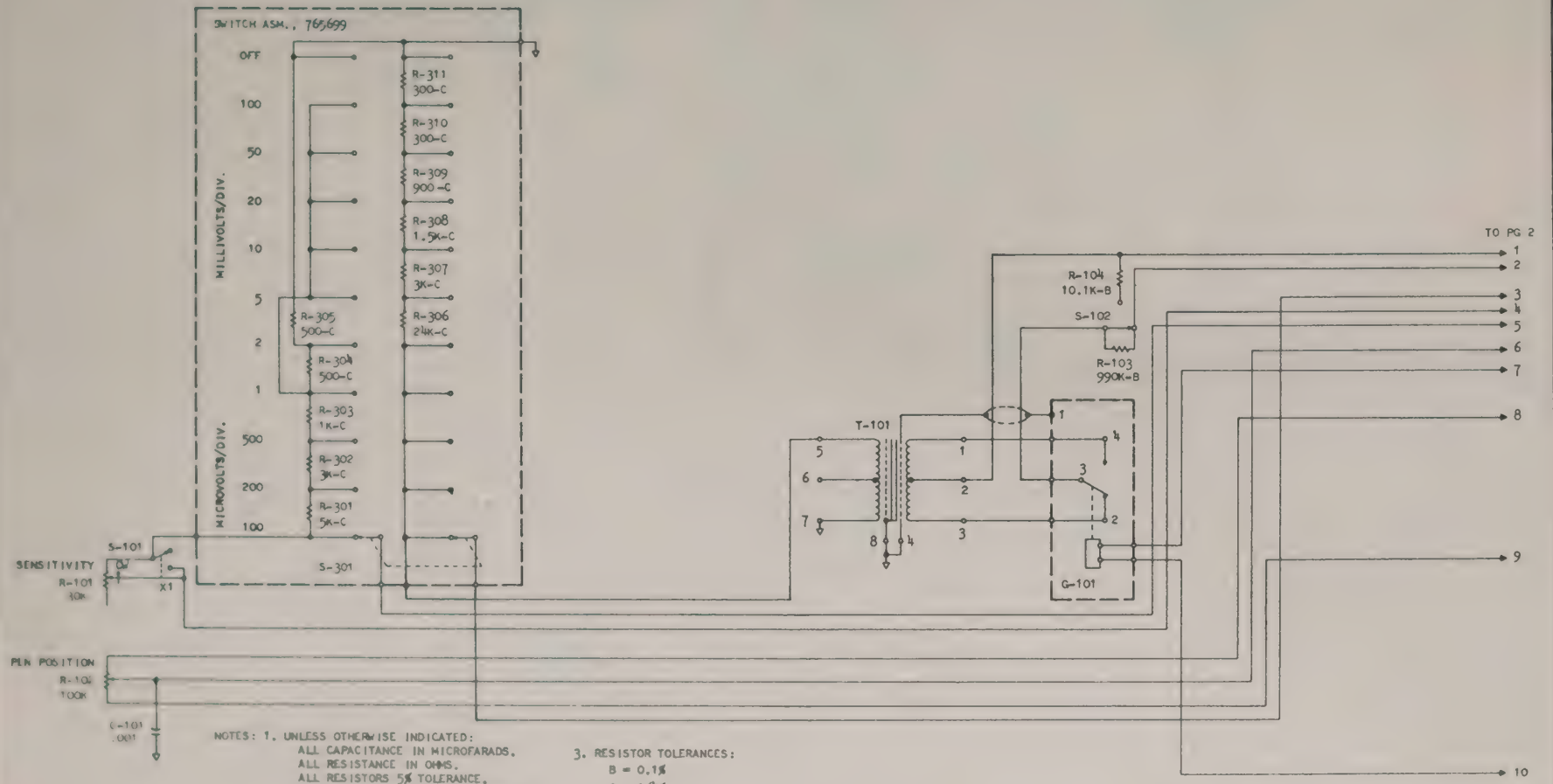
PREAMPLIFIER 13-4215-12

ZERO SUPPRESSION BOARD ASM. 765897

REV N-1



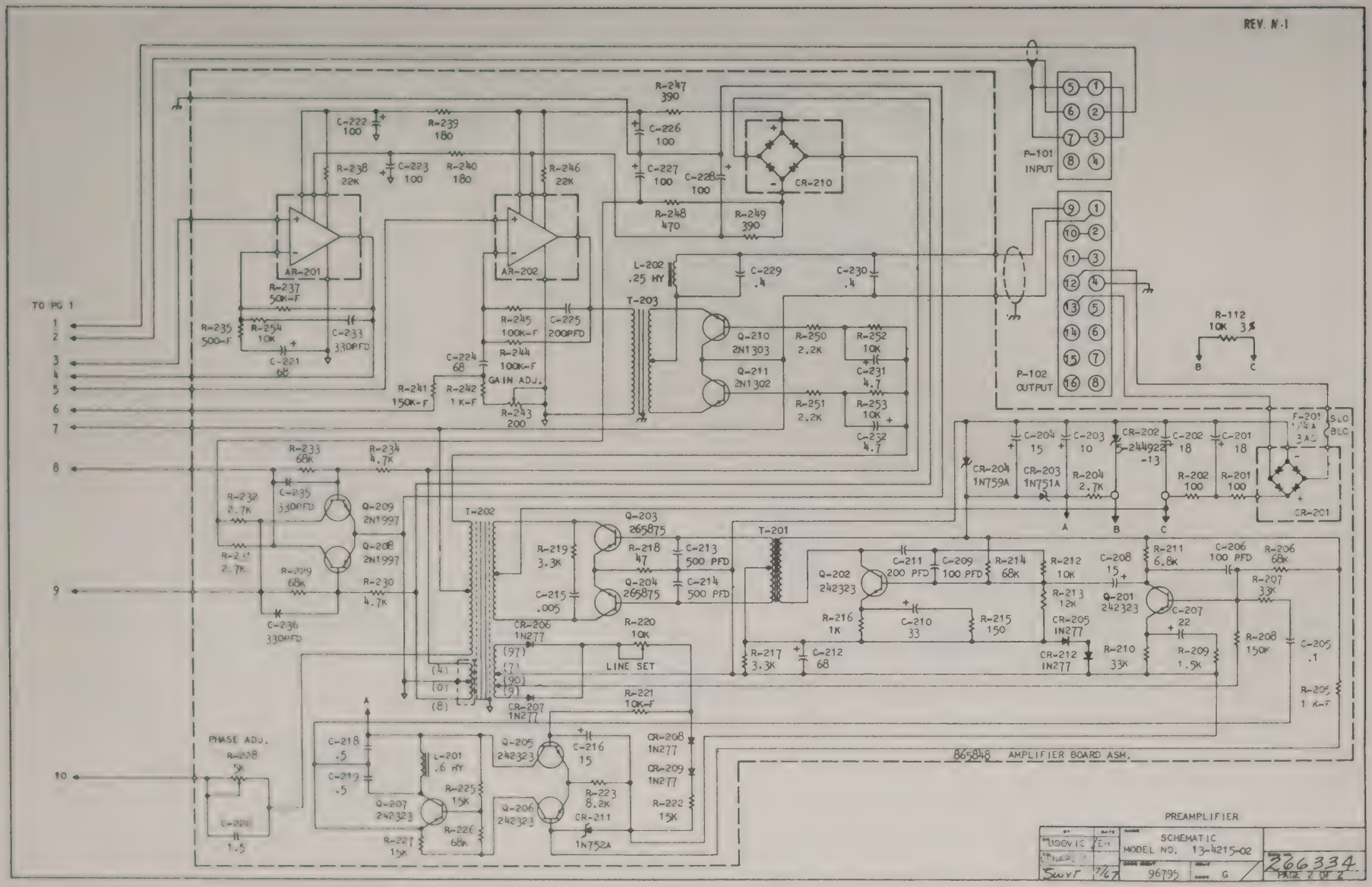
NOTES: 1. UNLESS OTHERWISE INDICATED:
ALL CAPACITANCE IN MICROFARADS.
ALL RESISTANCE IN OHMS.
ALL RESISTORS 5% TOLERANCE.
ALL VOLTAGES REFERENCED TO GROUND.
2. WIRE COLORS IN EIA COLOR CODE SHOWN IN PARENTHESIS ( ).

3. RESISTOR TOLERANCES:
B = 0.1%
C = 1/4%
F = 1%

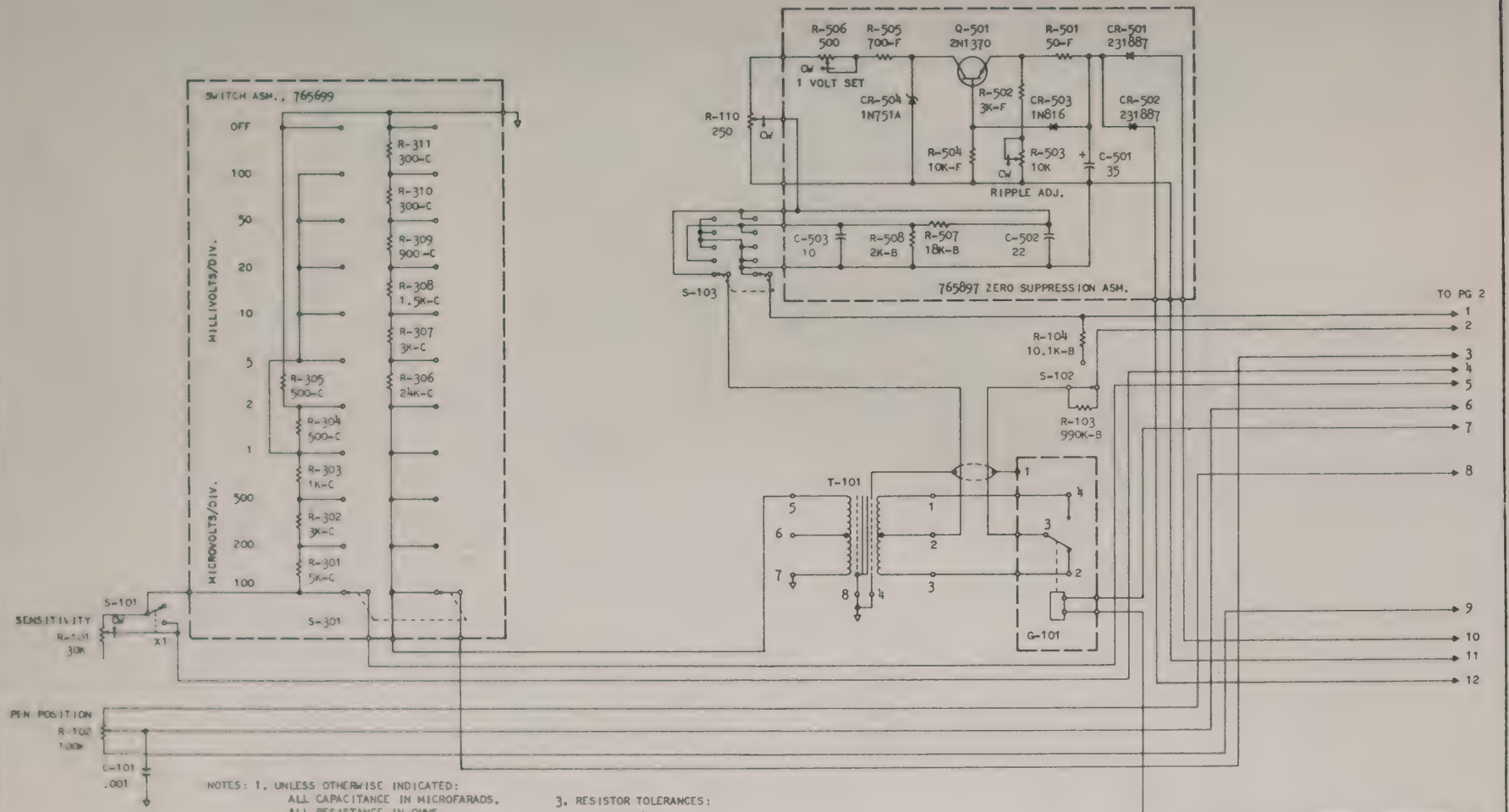
PREAMPLIFIER

BY: GOOVIS	DATE: EM	NAME: SCHEMATIC MODEL NO. 13-4215-02	
3 au YT	7/67	96795	CODE: G

DWG NO. 266334 PAGE 1 OF 2


REV. N-1
TO PG 1
P-101 INPUT
P-102 OUTPUT
AR-201
AR-202
T-203
T-202
T-201
Q-210 2N1303
Q-211 2N1302
Q-209 2N1997
Q-208 2N1997
Q-203 265875
Q-204 265875
Q-202 242323
Q-201 242323
Q-205 242323
Q-207 242323
Q-206 242323
CR-210
CR-201
CR-204 1N759A
CR-203 1N751A
CR-202 5-244922-13
CR-206 1N277
CR-207 1N277
CR-205 1N277
CR-212 1N277
CR-208 1N277
CR-209 1N277
CR-211 1N752A
L-202 .25 HY
L-201 .6 HY
R-112 10K 3%
LINE SET
PHASE ADJ.
GAIN ADJ.
865848 AMPLIFIER BOARD ASM.
PREAMPLIFIER
SCHEMATIC
MODEL NO. 13-4215-02
96795
266334
PAGE 2 OF 2

REV. P-1

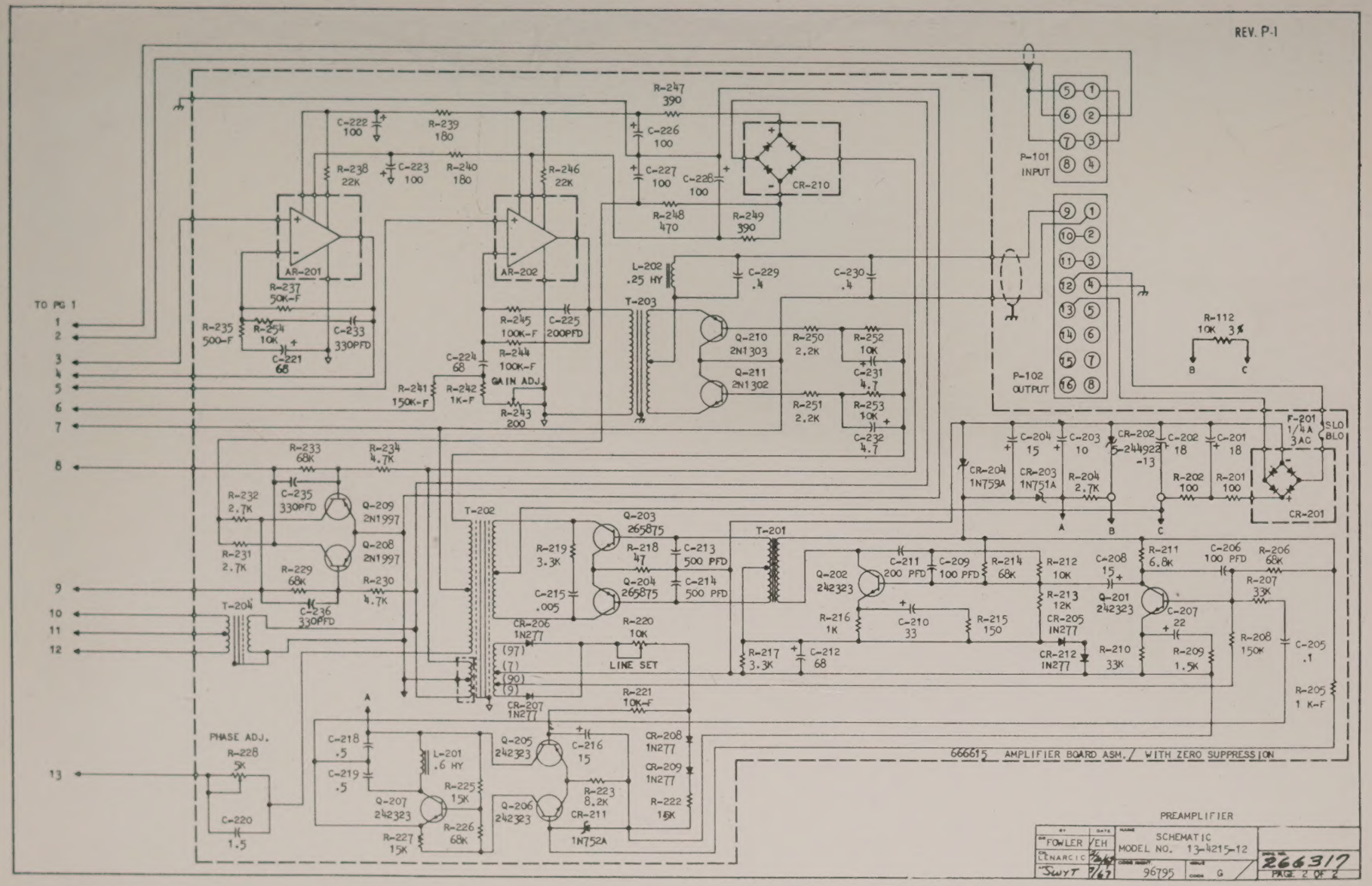


NOTES: 1. UNLESS OTHERWISE INDICATED:
ALL CAPACITANCE IN MICROFARADS.
ALL RESISTANCE IN OHMS.
ALL RESISTORS 5% TOLERANCE.
ALL VOLTAGES REFERENCED TO GROUND.
2. WIRE COLORS IN EIA COLOR CODE SHOWN IN PARENTHESIS ( ).

3. RESISTOR TOLERANCES:
B = 0.1%
C = 1/4%
F = 1%

PREAMPLIFIER

BY	DATE	NAME
FOWLER	EH	SCHEMATIC MODEL NO. 13-4215-12
CH. ENGR.		
JWT	7/63	SIZE A; DRAWING NO. 96795; REV. G; 866317; PAGE 1 OF 2


REV. P-1
TO PG 1
P-101 INPUT
P-102 OUTPUT
AR-201
AR-202
CR-210
T-203
T-202
T-201
T-204
Q-210 2N1303
Q-211 2N1302
Q-203 265875
Q-204 265875
Q-209 2N1997
Q-208 2N1997
Q-202 242323
Q-201 242323
Q-205 242323
Q-207 242323
Q-206 242323
GAIN ADJ
LINE SET
PHASE ADJ.
R-112 10K 3%
F-201 1/4A 3AG SLO BLO
CR-201
CR-202 5-244922-13
CR-203 1N751A
CR-204 1N759A
CR-205 1N277
CR-206 1N277
CR-207 1N277
CR-208 1N277
CR-209 1N277
CR-211 1N752A
CR-212 1N277
666615 AMPLIFIER BOARD ASM. / WITH ZERO SUPPRESSION
PREAMPLIFIER
SCHEMATIC
MODEL NO. 13-4215-12
FOWLER
LENARCIC
SWYT
96795
266317
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